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Psychological Monographs: General and Applied

Two Processes of Concept Formation[1]

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THIS STUDY is an experimental investigation of two processes of concept formation: Summation and Active Search. A comparison of these processes is carried out by studying the effects of a variety of different examples in each process.

General Theoretical Considerations

Theories of concept formation can be classified according to the kinds of processes to which they refer. Woodworth (37) divided theories of concept formation into two classes which he called composite photograph and active search. In the composite photograph process, "The features common to a class of objects summate their impressions on the observer who thus gradually acquires a picture in which the common features stand out strongly while the variable characteristics are washed out" (37, p. 801). By contrast, in the Active Search process, "The concept is supposed to originate as a hypothesis which *O* proceeds to test by trying it out on fresh specimens of the class" (37, p. 801).

Instead of the Composite Photograph process, we shall posit a more general process, Summation, in which summation and inhibition function as in the Composite Photograph process. However, no picture or image is assumed to be required. Summation is defined as a passive concept formation process which can function when no particular intent to form conceptions[3] is present, e.g., in "Spectator Behavior" as described by Heidbreder (12). In Spectator Behavior the *S* may either passively withdraw from the problem situation, or, as a possible path to concept formation, he may deliberately view the stimuli as if he were not attempting to learn a class concept.

In contrast to Summation, the Active Search process does depend on an intent to form conceptions. It involves the formulation of provisional solutions (hypotheses) which are tested on subsequent examples. "Participant Behavior" described by Heidbreder (12) exemplifies the Active Search process.

Although we agree with Vinacke (32) that the two behaviors, Spectator and Participant, can occur simultaneously, we shall examine the processes underlying them independently. Analysis of the

[1] Based on a dissertation submitted in partial fulfillment of the requirements for the doctoral degree at Clark University in 1957.

I want to thank the members of the thesis committee, Gordon T. Gwinn the chairman, who made invaluable contributions from the time of the inception of this study to its completion, and Richard S. Lazarus who was helpful throughout the difficult stage of writing the dissertation. Among others who made helpful contributions were Bernard Kaplan, John Lane, Seymour Wapner, Alastair Weir, Stephen Margulis, and Ann Schiller.

Without the assistance of my husband, Jerome E. Podell, who offered both moral encouragement and professional services, this study would not have been possible.

[2] Now at the University of California, Berkeley.

[3] We will use the term "conception" to refer to conceptual processes and the term "concept" as a logical abstraction which represents a class.

Active Search process will be based on Woodworth's description of hypothesis testing, and will bear certain resemblances to Postman's formulations (22). Gwinn's (10) Cognitive Conditioning Theory will be applied to the Summation process.

The Role of Variety in Concept Formation

Experiments on concept formation typically involve presenting objects (examples) which are members of a class and requiring *S* to form a conception of the class from these examples. Each example can contain two kinds of features: those which are common to all members of the class (*Common features*), and others which are not common (*Variable features*). Any object containing all the Common features is usually defined as an example of the class irrespective of the other features in that object.

Like Hull (15), Reed (26), Adams (1), and Robinson (29), we shall use the term Variety to refer to the number of *different* examples presented. Two objects are different examples of the same class when each has the common features of that class, but they differ in other characteristics (i.e., have different Variable features.[4] To illustrate Variety, consider the task of forming a conception of the class, dog. A small variety condition might involve the repeated presentation of only two examples—one a terrier and the other a pomeranian (Small Variety). Under a large variety condition, *S*s might be shown five different examples—terrier, pomeranian, hound, pekingese, and bulldog (Large Variety).

Frequency of practice is a function of the number of examples shown to the *S* without regard to the degree to which the particular examples are repeated. Hence, in any experiment on Variety in which the treatments are equated for Frequency, the Large and Small Variety treatments would consist of the same number of examples, but the former would consist of more different examples than the latter.

Our study deals with the effect of the Variety on concept formation. This variable was selected for study since it was possible to develop hypotheses about the effect of Variety on the two processes of concept formation. It was also felt that the two-process approach might clarify the existent controversy over the effect of Variety on concept formation.

A relatively small variety of examples appears to permit better learning in animals than does a large variety, vid., Robinson (29) and Fields (7). On the other hand, the effect of Variety for humans is less consistent, vid., Hull (15), Reed (26), and Adams (1).

It seems conceivable that different processes of concept formation could dominate in animals and humans. In animals, for instance, intent to learn might be minimal, and hypothesis testing, if present at all would probably be rudimentary and, of course, nonverbal. Thus, it seems reasonable to assume that the Summation process might be dominant in animals. Since Small Variety has led to superior learning in animals, we can hypothesize that, whenever Summation predominates, concept learning under Small Variety should be better than under Large.

For humans, on the other hand, sets to form class conceptions and test hypotheses should arise in any conventional concept formation experiment. Hence, the Active Search process should be domi-

[4] Examples for a small variety condition may be schematized as follows: rABCq and pABCd. A larger variety might consist of rABCq, pABCd, fABCl, mABCe, and hABCz.

nant in intentional human concept formation. Since the effect of Variety in humans is equivocal, and the two processes can operate simultaneously in human concept formation, it would be consistent if Active Search principles imply that Large Variety is superior.

Detailed examination of the studies of human concept formation (op. cit.) suggest that the disagreement over the effect of a Variety in human concept formation may be due to different experimental conditions in the various studies, e.g., kind of task, amount of practice, and the measure of concept formation employed.[5] We shall not attempt to resolve the controversy by considerations of these conditions in the various studies, but shall merely state the conditions of this study.

Our task involves successive presentaton of examples, learning of only one concept, and presentation in the Small Variety condition of more than one (different) example of the class. Frequency of practice was varied and several measures of concept formation were employed.

We shall analyze the way in which concept formation can come about under the two processes. In addition, we shall attempt to analyze the consequences of varying Variety on the "quality" of the class conception.

In general, the more Common features included and the greater the tendency to remember them, and on the other hand, the fewer Variable features included mistakenly, the "better" the class conception. *Inclusion in the class conception* means that *S* classifies the feature as Common.

[5] A more extensive review of the literature appears in the dissertation which is available as University Microfilm No. 23,903.

The Active Search Process

The Active Search process is characterized by hypothesis testing. In this process, *S* formulates hypotheses and tests them on succeeding examples. These hypotheses can be reduced to the general form: "Is 'this' feature common to all examples?" The presentation of an example may contradict or confirm an hypothesis.

Acceptance and rejection depend on confirmation and contradiction, respectively. Other things being equal, we can assume that the more confirmations an hypothesis receives, the higher the probability that *S* will conclude that the feature is common to all examples (accept his hypothesis).

Whereas one contradiction leads logically to rejection, psychologically, contradiction may not be final. Hence, we propose that the probability of "permanent" rejection increases with the frequency of contradiction while maintaining that contradiction has more "power" in decision making than does confirmation. Thus, the probability of permanent rejection following one contradiction should be greater than the probability of acceptance following one confirmation. In addition, retest of an hypothesis should be more likely after confirmation than after contradiction.

Concept formation by hypothesis testing.

Concept formation involves inclusion of features in the class conception. Inclusion of a feature is based on acceptance of the hypothesis mentioned above, i.e., is this feature common to all examples? Thus, like the probability of acceptance, the tendency to include a feature should increase with the number of occasions on which confirmation occurred.

Moreover, concept formation implies inclusion of Common features. Hypoth-

eses concerning Common features are confirmed more frequently than those concerning Variable features and are never contradicted. Therefore, the probability of accepting hypotheses should be greater for Common features than for Variable features. This, in turn, implies a stronger tendency to include Common features in the class conception.

Hypothesis testing should also facilitate remembering features. Frequency principles of learning suggest that, other things being equal, the more often an hypothesis is formulated and tested, the better it will be remembered. Since hypotheses concerning Common features should be retested more frequently than those concerning Variable features, we can conclude that Common features should be remembered better than Variable features.

Hypothesis testing and Variety

The role of Variety in concept formation will be considered with respect to: the tendency to remember and include Variable features in the class conception, and the tendency to remember and include Common features.

Variable features. Other factors being constant, Small Variety necessarily entails greater repetition of particular examples than does Large Variety. Consequently, hypotheses concerning particular Variable features should be confirmed more often and contradicted less often when Variety is small. Hence, *Ss* should be more likely to accept hypotheses concerning them under Small Variety conditions. Thus, the tendency to include particular variable features should be stronger for *Ss* in the Small Variety condition than in the Large. Since hypotheses concerning Variable features should be tested more frequently, Variable features should be remembered better also.

Ss should continue to test hypotheses, but as the supply of untested (new) hypotheses diminishes, retesting should increase. According to an earlier principle, retesting of an hypothesis concerning a Variable feature is more likely to permit contradiction of a previously accepted hypothesis in the Small Variety condition than in the Large. Thus, when Variety is Small, increase of Frequency should permit the correction of false acceptances. Thus, Small Variety should be more conducive to including Variable features than Large Variety, but this unfavorable effect should decrease with Frequency. Although there are fewer Variable features under Small Variety, the stronger tendency to remember particular Variable features should result in memory for more Variable features when Frequency is low. However, as Frequency increases, more Variable features should be remembered under the Large Variety conditions.

Common features. Let us illustrate the effects of Variety on the tendency to include Common features by considering an hypothetical case of two *Ss*, one in a Large and one in a Small Variety condition. Assume that no examples are repeated in the former condition, but that every example is repeated for three consecutive trials in the latter. Assume further that, on each trial, *S* tests just one hypothesis concerning one feature. Suppose that the first hypothesis for each *S* concerns a Variable feature, and that each tests it on the second trial. Since Large Variety *S* would receive a different example, he could reject the hypothesis while the Small Variety *S* could not. The third trial could enable the Large Variety *S* to test a new hypothesis. Hence he would have tested more different hypothesis than Small Variety *S*.

As a consequence of the argument il-

lustrated by the above example, we can conclude that Large Variety should lead to the testing of a greater number of different hypotheses than Small Variety. Assume that, other things being equal, the probability of testing an hypothesis concerning any feature is a function of both the number of features in each example and the number of examples in which it occurs. This assumption does not imply that Variety should not affect the probability of testing hypotheses which concern Common features. However, since more different hypotheses should be tested under conditions of Large Variety, more hypotheses concerning Common features should be tested and thus more Common features should be included in the class and remembered under Large Variety.

The Summation Process and the Cognitive Conditioning Theory

In this section, we will discuss concept formation in the Summation process and the way in which it is affected by Variety.

Concept formation by Summation

Gwinn's (**10**) Cognitive Conditioning Theory is similar to, but more detailed than, other Composite Photograph theories. The theory contains two postulates which are in themselves a statement of the Summation process. The first, a summation postulate, states that there is a summation of all elements common to concurrent cognitive responses. Cognitive responses are defined as perceptual or conceptual responses. This postulate implies that "common features stand out" (**37**, p. 801).

Gwinn's theory also contains postulates which state the conditions under which conceptual responses will occur and be remembered. These imply that, once two cognitive responses have occurred concurrently, the later occurrence of any cognitive response having elements in common with one of the original responses will tend to evoke a partial reproduction of the other. When this reproduction, which is a conceptual response, occurs, we say remembering has then taken place.

Furthermore, Gwinn's theory implies that the more often an example is repeated, the more frequently the features in it occur together and the more a subsequent perception or conception of any one feature should tend to evoke conceptions (recall) of the others in that example. When an example is presented to *S*, he should perceive all of its Common and Variable features although he may not pay attention to all of them. In any set of examples, Common features occur together with one another and with Variable features more often than do Variable features. Hence, Common features should be remembered better than Variable features.

Hypotheses about the tendency to include features are derivable from the postulates which relate to memory. If the memory for a feature is relatively strong, *S* would be more likely to think that he has seen it on every example than if memory were weak. However, when memory becomes very strong, *S* would know know how frequently it did occur. This suggests that he would ultimately recognize that a feature was not included since he remembered it so well. Consequently, let us assume that the tendency to include features increases with the tendency to remember them, reaches a maximum, and then reverses.

Since memory for Common features should be better than memory for Variable features, the tendency to include them in the class conception should be

stronger. Thus, we have shown briefly how the Summation process can lead to concept formation in that Common features should be remembered better than Variable features and more of them should be included.

Summation and Variety

Next, consider the role of Variety with respect to the tendency to remember and include Variable features, and the tendency to include Common features.

Each time an example appears, all Common features and all Variable features in the example are paired with each other. Since Small Variety entails more repetition of examples than Large Variety, the tendency for perceptions or conceptions of either Common or Variable features to evoke conceptions (memory) of other features should be greater. More concretely, Small Variety should lead to a greater tendency than Large Variety to remember and include both Common and Variable features.

This implies that the Small Variety condition should lead to remembering and including more Common features than the Large Variety condition to the point that they are all remembered and included. However, with respect to Variable features, it would only be true that more Variable features would be remembered and included under Small Variety conditions when Frequency is low. The number of Variable features included should continue to increase with Frequency until memory becomes very strong. At this point, Ss would no longer include features falsely. Since there are more Variable features in the Large Variety than in the Small, there is a point at which the Large Variety can lead to including and remembering more Variable features than the Small Variety.

General Hypotheses

The hypotheses derived from the analyses of the Active Search and Summation processes provide the framework for the experimental study.

The two processes should differ with respect to the effect of Variety on the learning of Common features. In the Active Search process, the tendency to remember and include particular Common features in the class conception should be greater under the Large Variety condition than the Small, whereas for the Summation process, this tendency should be greater under the Small Variety condition. In addition, in the Active Search process, a greater number of Common features should be remembered and included in the class conception under the Large Variety condition than the Small, but for the Summation process, this effect is reversed. That is, more Common features should be remembered and included for the Small Variety condition than for the Large.

Certain effects of Variety are the same with respect to learning of Variable features under the two processes. In general, the tendency to remember and include particular Variable features should be greater under the Small Variety condition than the Large. With respect to number of Variable features, the effect of Variety should depend upon Frequency. When Frequency is low, more Variable features should be remembered and included under conditions of Small Variety as compared to Large. However, as Frequency increases, this effect should reverse, i.e., more Variable features should be remembered in the Large Variety condition.

With respect to the tendency to include Variable features, the processes should diverge as Frequency increases.

In the beginning, more Variable features should be included under conditions of Small Variety for both processes. For the Active Search process, Small Variety would always tend to include more, whereas for the Summation process, the point can come where the Large Variety can lead to including more Variable features.

Methods

The purpose of this experiment was to investigate the effect of Variety on concept formation as mediated by two processes, viz., Active Search and Summation. In addition, since the effect of Variety may depend on the Frequency of practice, both Variety and Frequency will be studied.

We assumed that the Active Search process would be dominant for Intentional learning, and conversely, that Summation would be dominant for Unintentional learning. Accordingly, two sets were selected; an intentional set under which *S* was to deliberately form a concept, and an unintentional set under which artistic judgments were to be made.

Experimental Arrangements

The experiment consisted of three parts: the Learning Series, in which examples (designs) of the concept were shown; the Definition Test; and the Generalization Test. Conditions of Set, Variety, and Frequency were experimentally varied during the Learning Series, but testing conditions were constant for all *Ss*.

Subjects

Thirty-two white male summer school students at Clark University between 17 and 32 years of age were the subjects for the present experiment. They volunteered and were paid for their participation.

Apparatus and room arrangement

The stimuli (designs) appeared as projected white line drawings on a dark background. They were drawn with black india ink on white tracing paper, photographed, and the negatives mounted in 35 mm. glass slide binders. A TDC Vivid Projector with a changer was used to project these slides onto a cardboard screen at a distance of six feet. An episcotister which controlled both the exposures and the time between exposures for the Learning Series was placed in front of the projector. The episcotister was a semi-disc which rotated once every five seconds so that each slide was exposed for 2½ seconds followed by 2½ seconds of darkness during which *E* changed slides.

S was seated at a table at the rear of the experimental room; *E* sat to the right of *S* at another table on which the projector was placed. The distance between *S* and the screen was about 8 feet; the size of the projected image was about 13" x 16". The room was darkened during the Learning Series.

Experimental design

A triple classification factorial design was employed using independent groups of subjects. The three variables were Set, Variety, and Frequency, each of which was presented at two levels. *Ss* were randomly assigned to conditions, with the exception that the Moderate Frequency condition was completed before the Low Frequency condition. In order to assure adequate object sampling from a population of examples which we could not assume to be equal in facilitation of concept formation, we employed two different sets of stimuli. These were used in such a way that half of the subjects in each cell (2) received one set of stimuli and the other half (2) received the other set.

The stimuli

All *Ss* were presented with examples of a class of design from which they were to learn the characteristics of that class. The following features were known to be common to the examples (see Fig. 1).

1. A large free form line drawing.
2. A small free form inside the large free form.
3. A triangle containing a cross-hatched pattern inside the large free form.
4. A triangle outside the large free form whose apex was in contact with either the top or bottom edge of the large free form.
5. An appendage (unspecified shape) touching the top edge of the large free form and extending outside.
6. An appendage (unspecified shape) touching the right end of the free form.

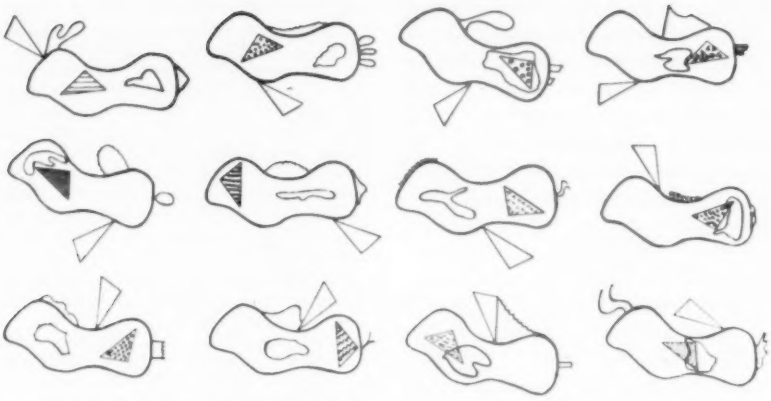

FIG. 1. One Large Variety (Twelve Examples) of Zareg. The first two examples in the top row comprised the corresponding Small Variety.

The following restrictions were observed in constructing the sets of examples:

1. Half of the examples had the outside triangle touching the top surface of the large free form, and the other half had it touching the bottom surface.
2. The appendage on the top surface was different in every different example of the class.
3. The appendage on the right end was different in every different example.
4. The pattern inside the triangle was different in every different example in each set.

The Learning Series

All *Ss* received one set of instructions followed by the successive presentation of designs appropriate to one of the Variety and Frequency conditions.

Set

Different sets were established by varying the instructions given to different groups. The *Intentional Set* was induced in one group of *Ss* by instructing them to form a concept as follows:

> You will see a group of designs projected one at a time on the screen. We are calling all these designs Zaregs to indicate that they are all examples of the same class of designs. Each time you see a design, try to notice all the things it has in common with all the other designs. That is, try to get a general feeling for how the designs look on the whole by noticing the ways in which the designs are alike. Now, just look at them and try to notice the ways in which they are alike or similar.

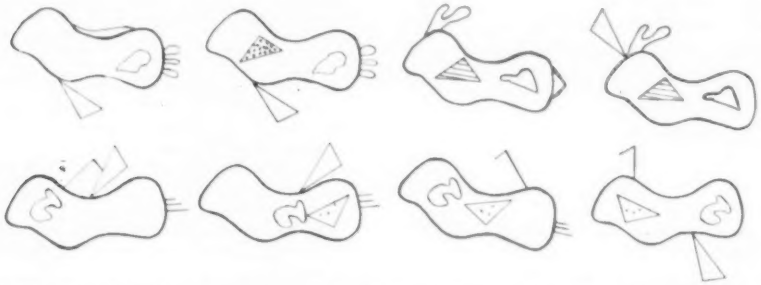

FIG. 2. The Test Stimuli for the Large and Small Variety illustrated in Fig. 1. The top row consists of Familiar Stimuli, and beneath each Familiar Stimulus is shown the corresponding New Stimulus.

In another group the *Unintentional Set* was produced by instructing the *Ss* to make artistic judgments as follows:

> You will see a group of designs projected one at a time on the screen. We are calling all these designs Zaregs to indicate that they are all examples of the same class of designs. So don't expect them to be widely different from each other. Each time you see a design, try to get a feeling of whether you like it or not and, in addition, try to get a general impression of how much you like them on the whole. The reason for this is that, later, when I show you the designs again, I want you to say about each one, either, "I like it better than Zaregs on the whole," or, "I like it less well than Zaregs on the whole." Do not try to make these judgments now. Just look at the designs and try to get a feeling of like or dislike for each drawing and for the drawings on the whole.

Variety

The Large Variety contained 12 examples while the Small Variety contained two examples. Two different sets of 12 (Large Variety) were obtained by drawing one set at random from a larger set of 24 different examples, thus producing two sets of 12 examples. Each pair of examples for the Small Variety conditions was obtained by drawing two examples at random from each Large Variety set. Thus, one Large and one Small Variety had examples in common and may be said to correspond.

Two random orders were used, one for each Variety condition. Different examples were assigned to the same order positions in the two different sets of examples. Thus, the two sets of examples provided a control for examples and to some extent, order.

Frequency

Ss in the Moderate Frequency condition received 24 trials, while only 12 trials were given in the Low Frequency condition. The random order which was used for the Low Frequency condition was given and then reappeared in reverse for the Moderate Frequency condition.

The Definition Test

A verbal definition of the concept was requested from all *Ss*. It was scored separately in terms of the number of Common and Variable features mentioned.

Administration of the Definition Test

Prior to the request for definition, the Unintentional group was prepared for such a request in the following way:

> What we are really studying in this experiment is what people learn while they make artistic judgments. This will be a very, very difficult thing for you to do, and you are not expected to have learned very much when you were not really trying to learn. Now, all the designs you have already seen were called Zaregs because they were all examples of the same class of designs and were thus alike or similar in some ways.

Both groups were instructed as follows:

> Please write down all the things you can think of that are common to all the designs you have seen. Remember that we are calling these designs Zaregs, so by writing the ways in which they are similar, you are writing all the things a design would have to have in order to be called a Zareg. So list as many properties common to the designs you have seen that you can remember.

When necessary the instructions were paraphrased to assure comprehension.

Scoring of the definitions

Features mentioned in a definition must have been remembered and included. Although only Common features are in the abstract concept, both Common and Variable features occur in the psychological conception. The system for scoring the number of Common and Variable features follows.

The number of Common features mentioned. We divided our own description of the Common features into idea units

which we considered compound Common features, e.g., triangle, located within the large free form; pattern, contained within the triangle. Furthermore, each of these compound Common features was thought to represent more than one feature and was arbitrarily scored 2. If part of a compound feature was mentioned, we scored *S*'s response 1, but if he described the complete compound feature, we scored his response 2.[6] Thus "angular figure" and "either stripes or dots" were scored 1, and "triangle" and "pattern" were scored 2. If *S* mentioned a compound Common feature which was not on our original list but could be seen as Common, it was added to our list of compound Common features. Since we were mainly concerned with the number of Common features included and not with the certainty with which they were included, we made no distinction in our scoring system between features which were definitely and tentatively included. Thus, the more Common features mentioned, the higher the score.

The number of Variable features mentioned. Similar to the scoring of Common features, we scored our Definition Test with respect to the number of Variable features mentioned. Each compound Variable feature mentioned was scored 2 and if only part of that compound feature was included, it was scored 1. In addition, as with Common features, no distinction was made between definite and dubious statements. Features described in the definitions but not discernably characteristic of any example were scored 0. These were errors of reproduction which could have represented tendencies other than to remember and include Variable features in the conception. In addition, if *S* listed Variable features as merely illustrative of the way in which the Common features could appear, and he stated the Common features, he was not scored for the Variable features. For instance, if *S* said that the triangle "contained a pattern" (Common features) and that "for example, the pattern could be dots, stripes, or other," he was scored 0 for Variable features. However, if he said that "the triangle contains either stripes or dots," he was scored 4 since he "included" two compound Variable features. The more Variable features mentioned in *S*'s definition, the higher the total score.

Hypotheses relating to the Definition Test

We already mentioned that, when asked to define a concept, *S* would be likely to mention all the features which he included in his class conception and remembered at the time of testing. The features mentioned could be either Common or Variable. The general hypotheses presented earlier deal directly with the requirements of the Definition Test in that they are stated in terms of the number of Common and Variable features which *S*s should remember and include in the class conception.

Relating our theoretical hypotheses to performance on the Definition Test, we should find that, whenever Common (or Variable) features tend more to be remembered and included under one condition than another, more Common (or Variable) features should be mentioned

[6] If *S* specified "angular figure" instead of triangle, we felt that he had included some Common features in his conception, but that he included fewer Common features in his conception than the *S* who mentioned "triangle" specifically. In addition, the *S* who reported that the triangle contained "either stripes or dots" had specified that "something" was inside the triangle, but he had not mentioned all the features contained in the general term "pattern." In other words, we maintain that the general term represented something more than the specific examples of it.

in the definition under that condition. Furthermore, the mentioning of more Common (or Variable) features could come about by a stronger tendency to either include or remember that kind of feature.

On the basis of our theoretical considerations, we can hypothesize concerning the mentioning of Common and Variable features on the Definition Test, e.g., for the Active Search process, Large Variety should promote the mentioning of more Common and fewer Variable features than the Small Variety; for the Summation process, Small Variety should promote mentioning both more Common and more Variable features.

The Generalization Test

This test was designed to measure recognition of Common and Variable features as the basis for generalization.

The Generalization Test Stimuli

All of the test stimuli had all of the Zareg Common features except that one compound Common object was deleted. An object is the smallest collection of features which can be removed conveniently.[7] The test stimuli were of two kinds, *Familiar* and *New*. The Familiar Stimuli contained the same Variable features as those which the *S* had already seen while the New Stimuli contained Variable features which were different from those which had already been seen.

There were two versions of the Generalization Test, one for each set of designs. A Large Variety condition and the Small one corresponding to it received the same Generalization Test. There were eight stimuli in each test, of which four were Familiar and four were New. Every test stimulus had one Common object (compound Common feature) deleted, but only four different compound Common objects were deleted in the set as a whole, i.e., "inside" triangle, "outside" triangle, right end appendage, and top appendage. For each Familiar Stimulus that had a certain compound Common object deleted, there was a New Stimulus with the same object deleted.

One random order of the eight test stimuli was used, and the stimuli were repeated in the same random order. Thus, each *S* judged each test stimulus twice.

Administration of the Generalization Test

*S*s were told to rate the designs according to how similar they were to examples of the class Zareg as follows:

> All the designs you have already seen are Zaregs. Now I am going to show you some designs which are either examples of the class Zareg or similar to examples of the class Zareg. Every time you see a design, decide whether it is a Zareg, is very, very similar to Zaregs, similar to Zaregs, slightly similar to Zaregs, or not similar to Zaregs.

E handed *S* a card on which the categories for judgment were listed with a number corresponding to each category ranging from 5 (it is a Zareg) to 0 (it is not similar to Zaregs). The instructions were paraphrased if necessary.

Each slide was presented for approximately five seconds,[8] and the interval between slides was approximately two seconds.[9]

Scoring of the Generalization Test

We obtained two scores for each *S*; the total scores for New and Familiar Stim-

[7] Obviously, when "triangle" was removed, "inside the free form" was necessarily removed also.

[8] *E* counted to 10 after having standardized that count, in order to control the exposure time in the Test Series.

[9] *E* attempted to change slides as quickly as possible after recording the response. The time between exposures was approximately, though not exactly, controlled at about two seconds.

uli. The scores measure the degree of generalization to that kind of stimulus. The higher the score, the more similar the subject judged the stimuli to his conception of Zareg, and the lower the score, the less similar he judged the stimuli to Zareg.

We will consider two ways in which the test can be performed, the Recognition Method and the Analytical Method. In the Recognition Method, the similarity between the stimulus and the conception depend on how well *S* recognizes the stimulus. Since *S* was told that all the stimuli which he had previously seen were Zaregs, he could assume that any stimulus which he recognized was a Zareg. In general, the more features *S* recognizes, the more similar to the concept he should judge the stimulus.

In the Analytical Method, *S* seeks to determine whether the features which are in his class conception are in the test stimulus. In order to do this, he must include features in his conception as well as remember them. In general, of those features which are in the test stimulus, the more features *S* remembers and "includes," the more similar to his conception he should judge the test stimulus to be.

Although it is reasonable to assume that both methods would be used, the time limit was such as to make performance according to the Analytical Method difficult. Therefore, we shall assume that the Recognition Method was used predominantly. This will permit us to interpret our results in terms of the relative number of features remembered by the various treatment groups. It is of interest that interpreting in this way does not preclude the operation of the Analytic Method but comprises part of it since both methods involve remembering features similarly.

With respect to Familiar Stimuli, *all* the features in it are Familiar. Hence, generalization to these stimuli could be based on remembering either Variable or Common features, or both. New Stimuli, however, contain only "previously seen" Common features. Thus, generalization to these stimuli should depend more on remembering previously seen Common features. Conversely, a greater tendency to remember Variable features should accompany a weaker tendency to generalize to New stimuli. This can come about by the fact that *S* can notice the absence of certain features or the unfamiliarity of the stimulus.

Summary of Methods

In the Intentional conditions, *S*s were instructed to learn the features common to designs they were about to see, but in Intentional conditions, *S*s were instructed to make artistic judgments about the designs. All *S*s were shown designs one at a time (Learning Series), following which they wrote a verbal definition of the concept which the designs exemplified (Definition Test). A second test was then administered (Generalization Test) in which *S*s were shown other designs which they were to rate according to how similar they were to the concept. These designs were of two kinds, Familiar (having previously seen Variable features) and New (having Variable features which did not appear in any of the original designs). All test stimuli contained all but one of the Common objects (objects in the concept).

The Variety and Frequency conditions differed with respect to certain characteristics of the Learning Series. The Large Variety contained more different examples than the Small Variety, and in the Moderate Frequency condition the total number of examples presented was

TABLE 1

THE MEAN NUMBER OF COMMON FEATURES MENTIONED IN THE DEFINITION FOR VARIETY AND SET CONDITIONS**

		Variety	
		Large	Small
Set	Unintentional	7.12	11.87
	Intentional	17.37	10.37

Note.—Separate t tests using the error term from the Analysis of Variance revealed that (a) the difference between the Variety conditions for Unintentional Set was significant $P < .02$, (b) the difference between the Variety conditions for Intentional Set was significant $P < .01$, and (c) the difference between Sets for the Large Variety conditions was significant $P < .01$ (**6**, **21**).

** Interaction of Variety and Set was significant at less than the .01 level.

larger than in the Low Frequency condition.

RESULTS AND DISCUSSION

The Definition Test

The number of Common features mentioned. With respect to Variety, our hypotheses implied that *Ss* in the Large Variety condition should mention more Common features for the Intentional Set, but for the Unintentional Set, *Ss* in the Small Variety condition should mention more Common features than those in the Large. This was supported by our results which included a significant interaction between Variety and Set (see Table 1 and Table A of the Appendix[10]).

This result supports our theoretical hypotheses (a) that the Active Search process should lead to remembering and including more Common features than Small Variety and (b) that, under the Summation process, Small Variety should lead to remembering and including more Common features than Large Variety.

Although we did not directly hypothesize a difference between Intentional and Unintentional learning, we obtained a main effect of Set which is compatible with our formulations. On the average, more Common features were mentioned under Intentional Set. It is important to note that, consistent with our hypotheses concerning the Variety and Set interaction, this difference obtained only for the Large Variety conditions (see Table 1).

The number of Variable features mentioned. We hypothesized that regardless of Set, when Frequency is relatively low, Small Variety should lead to mentioning more Variable features than Large Variety. However, this effect was expected to diminish with increase of Frequency (and ultimately to reverse in the case of the Summation process). We found that, on the average, under the Small Variety conditions, *Ss* mentioned more Variable features than under the Large Variety conditions. This was shown by a significant main effect for Variety (see Table 2 and Table B of the Appendix).

Let us assume that both of our Frequency conditions were low since this result was compatible with our theoretical hypotheses which related to low frequency. Furthermore, we have independent support for this assumption in that a small proportion of the possible number of Common features were mentioned in the Definition Test. Viewed in this light, this result provides support for our

TABLE 2

MEAN NUMBER OF VARIABLE FEATURES MENTIONED IN THE DEFINITION TEST FOR THE VARIETY CONDITIONS*

Variety	Large	2.00
	Small	3.75

* A separate t test based on the error term of the Analysis of Variance indicated that the difference between means was significant $P < .02$ (**6**, **21**). This main effect was significant at less than the .05 level.

[10] All statistical tests performed were two tailed.

TABLE 3

MEAN NUMBER OF VARIABLE FEATURES MENTIONED IN THE DEFINITION TEST FOR THE VARIETY, SET, AND FREQUENCY CONDITIONS*

		Variety			
		Large		Small	
		Moderate Frequency	Low Frequency	Moderate Frequency	Low Frequency
Set	Unintentional	2.50	3.50	6.75	4.50
	Intentional	1.00	1.00	0.75	3.00

Note.—t tests using the error term from the Analysis of Variance indicate that any differences over 2.64 are significant $P < .05$ (**6**, **21**).

* Interaction significant at less than the .05 level.

theoretical hypothesis that early in practice, more Variable features should be included and remembered under Small Variety conditions irrespective of the process of concept formation.

The effect of Variety and Set with respect to the mentioning of Variable features depended on Frequency. In general, its effect was greater for the Small Variety conditions than for the Large. Considering only Small Variety, increasing Frequency resulted in the mentioning of more Variable features for the Unintentional conditions, but for the Intentional condition, the number of Variable features mentioned decreased. This was shown by a significant triple interaction between Set, Variety, and Frequency (see Table 3 and Table B of the Appendix).

We hypothesized that the tendency to include features should increase until memory becomes strong (concomitant with high frequency) under the Summation process, while this tendency should decrease very early (from the first contradictions) under the Active Search process. Therefore we can conclude that, for Small Variety, the tendency to include Variable features begins to decline more quickly under the Active Search process than under the Summation process.

Although we did not directly hypothesize a difference between Intentional and Unintentional conditions, we did obtain a main effect of Set (see Table 4 and Table B of the Appendix) which indicates that, for all Variety and Frequency conditions, the Unintentional Set led to mentioning more Variable features than the Intentional Set.

It seems consistent with our other intrepretations to speculate that, in general, the tendency to include Variable features is greater under the Summation process.

The Generalization Test

This test was designed to shed light on generalization to New and Familiar Stimuli. More specifically, differences between conditions in terms of the tendency to remember Variable and Common features were thought to be reflected by this test.

Variety. We said that the greater the tendency to remember Common or Variable features, or both, the greater the tendency to judge Familiar Stimuli as similar to the concept. In addition, the stronger the tendency to remember Variable features, the greater the generalization to New Stimuli.

TABLE 4

MEAN NUMBER OF VARIABLE FEATURES MENTIONED IN THE DEFINITION TEST FOR THE SET CONDITIONS**

Set	Unintentional	4.31
	Intentional	1.43

** A separate t test using the error term from the Analysis of Variance indicated that the mean difference was significant $P < .01$ (**6**, **21**). This main effect was significant at less than the .05 level.

TABLE 5

MEAN SIMILARITY JUDGMENTS OF NEW AND FAMILIAR STIMULI IN THE LARGE AND SMALL VARIETY CONDITIONS**

		Variety	
		Large	Small
Stimuli	New	2.81	2.31
	Familiar	2.85	3.60

Note.—The scores represent the average score for each *S*.

** *t* tests using the error term from the Analysis of Variance indicated that (*a*) the difference between means of the Variety conditions was significant $P < .01$ for Familiar Stimuli, (*b*) the difference for New Stimuli was not significant ($P < .06$), (*c*) the difference between New and Familiar Stimuli was significant for the Small Vatiety condition $P < .01$, and (*d*) the difference for the Large Variety condition was not significant (**6**, **21**). The interaction was significant at less than the .01 level.

As would be expected, Familiar Stimuli were judged more similar to Zareg than New Stimuli for all conditions. In addition, the difference in similarity judgments between New and Familiar Stimuli was greater for Small Variety than for Large. New Stimuli were judged less similar and Familiar Stimuli more similar when Variety was Small than when it was Large. This result (see Table 5 and Table C of the Appendix) may be accounted for by the hypothesis that the tendency to remember Variable features should be greater for Small Variety conditions than for Large Variety conditions.

Frequency. An analysis of variance (see Table C of the Appendix) indicates that there was a main effect of Frequency in that *S*s in the Moderate Frequency condition rated both New and Familiar Stimuli as more similar to the concept than did *S*s in the Low Frequency condition (see Table 6). This suggests that, as hypothesized, memory for Common features increases with Frequency.

Set. No reliable differences relevant to generalization were found.

Summary and Integration of Results

Set, Variety, and Frequency were found to affect concept formation. Set determined the way in which Variety affected concept formation in that, for Intentional Set, Large Variety led to the mentioning of more Common features, while for Unintentional Set, Small Variety had the same effect. We accepted the hypothesis that, for the Active Search process, Large Variety should lead to remembering and including more Common features, while for the Summation process, Small Variety should have this effect.

More Variable features were mentioned in the Definition Test under Unintentional Set. From this we can infer that the Summation process led to including more Variable features than the Active Search process.

The tendency to include Variable features was especially great for the Small Variety conditions, but for the Summation process, the tendency to include them increased with Frequency, while for the Active Search process, it decreased. Thus, Variety determined the tendency to include Variable features, but the effect also depended on Frequency and Set.

Variety also affected memory of Variable features. The mentioning of more Variable features on the Definition Test under the Small Variety condition was

TABLE 6

MEAN SIMILARITY RATING OF GENERALIZATION STIMULI FOR MODERATE AND LOW FREQUENCY CONDITIONS**

Frequency	Moderate	3.17
	Low	2.62

** A separate *t* test using the error term from the Analysis of Variance indicated that the mean difference was significant $P < .01$ (**6**, **21**). This main effect was significant at less than the .01 level.

consistent with the hypothesis. Furthermore, a finding from the Generalization Test permits us to conclude that memory for particular Variable features was stronger for the Small Variety conditions. The finding was that New Stimuli were judged less similar to the concept than Familiar Stimuli for the Small Variety, while the difference was smaller and not significant for the Large Variety.

Although we believe that both Frequency conditions represented a relatively low level of practice, we did find that, as practice increased, both New and Familiar Stimuli were judged more similar to the concept. This is accounted for by the hypothesis that memory for Common features increases with Frequency.

Conclusions

The main problem of this study concerns the operation of two processes of concept formation. Earlier we made the assumption that the Active Search process would be dominant for the Intentional concept formation and the Summation process would be dominant for Unintentional concept formation, while maintaining that both processes could occur simultaneously. A more refined notion of their relationship involves the notion that Summation is constantly in operation while the Active Search only occurs relevant to a definite special set. When it does occur, however, it can overshadow Summation, and this is what we assumed to occur in Intentional concept formation.

It seems reasonable to suppose that Summation did not occur alone under Unintentional concept formation. More specifically, an aesthetic set may have occurred simultaneously. However, it is our assumption that such a set would not play a selective role in concept formation or be such as to overshadow the operation of Summation. On the contrary, it is felt that Summation would be an integral part of an aesthetic set. Hence, our hypotheses concerning Summation should be relevant to the Unintentional Set as we have been assuming. However, the reader may prefer to entertain the notion that the obtained results for the Unintentional condition reflect the operation of an aesthetic set rather than Summation.

The greatest difference between the Active Search and Summation processes would seem to be related to the occurrence of contradiction in the former process. Confirmation was viewed as a gradual process culminating in acceptance of an hypothesis, and this gradualness is in effect similar to the strengthening of the tendency to remember features, which is characteristic of the Summation process. The power of contradiction, on the other hand, rests on the fact that it allows rejection of an hypothesis at once. In the Active Search process, the Large Variety condition permits the *S* to take advantage of the "power" since a larger proportion of the trials provide opportunity for contradiction. Thus more trials are available to test new hypotheses (including hypotheses concerning Common features). Conversely, in the Small Variety conditions, the *S* is less able to take full advantage of the "power" since more trials must occur before a contradicting event. Thus Small Variety should tend to minimize the different effects of the two processes. These theoretical notions were supported by the facts that the Intentional Set produced inclusion of more Common features than the Unintentional Set for the Large Variety conditions but not for the Small.

In general, we found that the differ-

ences between Intentional and Unintentional learning lay in a differential tendency to include features in the class conception rather than in a differential tendency to remember them.

Theoretically, inclusion and memory were considered part of the same process in Summation and relatively independent in the Active Search process. Results supporting this view may be seen in the effect of Frequency in the Small Variety condition. With increasing Frequency, both inclusion and memory increase under the Summation process. However, under the same conditions, inclusion decreases and memory increases under the Active Search process. Hence it seems reasonable to conclude that the tendencies to include features and remember them are more intimately related in the Summation process than in the Active Search process.

More concretely, this study enables us to draw conclusions concerning Variety. It demonstrates some differences between two processes of concept formation by comparing the effects of Variety of different examples and Frequency of practice in each process. It shows that concept formation can occur even in the absence of a specific intent, and that the characteristics of the particular conception depend on the conditions under which it was formed.

The "best" concept formation is attained by Ss under Intentional Set when Large Variety is presented. Under these conditions more Common features and fewer Variable features are included in the class conception. Conversely, when Variety is large and learning is Intentional, concepts are most complete and least overinclusive.

When Frequency of practice was low, there was no reliable effect of Set on the Small Variety conditions. However, with greater Frequency, a difference between the two Small Variety conditions appeared such that the number of Variable features included decreased under the Intentional Set.

The major implication of this study is that concept formation must be studied with respect to the kind of process which is occurring. We have analyzed two processes which have been described historically and have dealt with them in terms of two stimulus variables. This represents only a beginning. In order to construct comprehensive theories of concept formation, more stimulus variables must be considered in the light of these processes, and perhaps more processes must be isolated.

Summary

The purpose of this study was to investigate the role of the Variety of different examples and Frequency of Practice in two processes of concept formation: the Summation process and the Active Search process. An Unintentional (aesthetic) Set was used to produce the Summation process and an Intentional (hypothesis testing) Set was used to produce the Active Search process. These sets were instigated by verbal instruction.

A theoretical interpretation of concept formation under Intentional Set was developed by an analysis of hypothesis testing based on a description of Active Search Theories presented by Woodworth (37). Concept formation under Unintentional Set was interpreted in accordance with the Cognitive Conditioning Theory proposed by Gwinn (10). The two analyses yielded differential hypotheses concerning the effect of Variety on concept formation. The experiment was set up in order to test some of these hypotheses.

During the learning period, designs belonging to the same class (having features in common) were presented successively. Under the Unintentional Set *Ss* were to make aesthetic judgments about them, but under the Intentional Set they were to discover the features common to all the designs (Common features). Following the learning period, two tests of concept formation were administered (test period).

The first was a definition test in which *Ss* listed the features common to the designs they had seen. This provided a measure of the Common and Variable features in the *S*'s class conceptions to the extent that they were recalled. (Variable features are those which are not characteristic of all designs in the class.) The second was a generalization test in which *Ss* rated stimuli according to their similarity to members of the class. The test stimuli were similar to the original designs in that they had many of the Common features. One type of test stimuli had Familiar Variable features and another type had New Variable features. Generalization on this test was held to reflect memory for Common and Variable features.

During the learning period, *Ss* in the Small Variety conditions received only two different examples of the concept while those in the Large Variety conditions received 12 different examples. For Low Frequency, half as much practice was given as for the Moderate Frequency condition. Both Variety conditions were studied under two levels of Frequency.

It was found that the effect of Variety depended on Set in that, for Intentional Set, the Large Variety condition led to mentioning more Common features than the Small Variety, but for Unintentional Set, Small Variety produced the mentioning of more Common features in the Definition Test. With respect to mentioning Variable features, when Frequency was low, the Small Variety conditions under both Sets produced the mentioning of more Variable features than the Large Variety conditions. However, as Frequency increased, the Small Variety condition for Unintentional Set continued to produce the mentioning of more Variable features than the Large Variety condition, whereas for Intentional Set, the difference between the Variety conditions disappeared.

In general, the Unintentional Set led to mentioning fewer Common and more Variable features than the Intentional Set. However, no reliable evidence that they differed in terms of their respective tendencies to promote the remembering of Common or Variable features was obtained from the Generalization Test. We concluded that the two Set conditions differed in the tendency to promote the inclusion of Common and Variable features in class conceptions. However, with respect to Common features this difference between set conditions occurred for Large Variety but not for Small. With respect to the memory for features, we obtained evidence that the tendency to remember Common features increased with Frequency and also may have been greater for the Intentional Set. The tendency to remember Variable features, however, was greater under the Small Variety conditions irrespective of set.

We concluded that our results supported or were consistent with the hypotheses derived from separate analyses of the two processes. Differences between the processes were discussed.

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APPENDIX

TABLE A

THE NUMBER OF COMMON FEATURES MENTIONED IN THE DEFINITION TEST AS A FUNCTION OF SET, VARIETY, AND FREQUENCY

	df	Sum of Squares	*F*
Total	31	810.88	
Between Conditions	7	472.88	
Variety (V)	1	10.13	.72
Frequency (F)	1	3.13	.22
Set (S)	1	153.13	10.87*
V×F	1	15.12	1.07
V×S	1	276.12	19.61**
F×S	1	.12	.01
V×F×S	1	15.13	1.07
Between *Ss*[a] within conditions	24	338.00	

[a] Error term against which all main effects and first order interactions were tested.
* Significant at the .05 level or less on the basis of a two-tailed test.
** Significant at the .01 level or less on the basis of a two-tailed test.

TABLE B

THE NUMBER OF VARIABLE FEATURES MENTIONED IN THE DEFINITION TEST AS A FUNCTION OF SET, VARIETY, AND FREQUENCY

	df	Sum of Squares	*F*
Total	31	197.50	
Between Conditions	7	119.00	
Variety (V)	1	24.50	7.49*
Frequency (F)	1	.50	.15
Set (S)	1	66.12	20.22**
V×F	1	.50	.15
V×S	1	6.13	1.87
F×S	1	6.13	1.87
V×F×S	1	15.12	4.62*
Between *Ss* within conditions[a]	24	78.50	

[a] Error term against which all main effects and interactions were tested.
* Significant at the .05 level or less on the basis of a two-tailed test.
** Significant at the .01 level or less on th basis of a two-tailed test.

TABLE C

JUDGED SIMILARITY AS A FUNCTION OF VARIETY, SET, AND STIMULUS FAMILIARITY

	df	Sum of Squares	*F*
Total	63	3393.11	
Between *Ss*	31	1710.61	
a. Variety (V)	1	15.01	
b. Frequency (F)	1	310.64	6.31*
c. Set (S)	1	78.76	1.60
d. V×F	1	17.02	.34
e. V×S	1	19.15	.38
f. S×F	1	5.64	.11
g. V×F×S	1	83.26	1.67
h. Between *Ss* within cells[a]	24	1181.13	
Within *Ss*	32	1682.50	
a. Stimulus Familiarity	1	456.89	11.55**
b. *Ss* by SF[b]	31	1225.61	
(1) SF×V	1	395.02	12.68**
(2) SF×F	1	.01	
(3) SF×S	1	17.02	.54
(4) SF×V×F	1	6.89	.22
(5) SF×S×V	1	21.38	.68
(6) SF×F×S	1	37.52	1.20
(7) SF×V×S×F	1	.15	
(8) Pooled *Ss* by SF for each method group[c]	24	747.62	

[a] Error term against which a–g were tested.
[b] Error term against which a was tested.
[c] Error term against which b(1)–(7) were tested.
* Significant at the .05 level or less on the basis of a two-tailed test.
** Significant at the .01 level or less on the basis of a two-tailed test.